

The Triggering mechanism of coronal jets and CMEs: Flux Cancellation

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Abstract

Recent investigations^{2,4} show that coronal jets³ are driven by the eruption of a small-scale filament (10,000 - 20,000 km long, called a *minifilament*) following magnetic flux cancellation at the neutral line underneath the minifilament. Minifilament eruptions appear to be analogous to larger-scale solar filament eruptions: they both reside, before the eruption, in the highly sheared field between the adjacent opposite-polarity magnetic flux patches (neutral line); jet-producing minifilament and larger-scale solar filament first show a slow-rise, followed by a fast-rise as they erupt; during the jet-producing minifilament eruption a jet bright point (JBP) appears at the location where the minifilament was rooted before the eruption, analogous to the situation with CME-producing larger-scale filament eruptions where a solar flare arcade forms during the filament eruption along the neutral line along which the filament resided prior to its eruption. In the present study we investigate the triggering mechanism of CME-producing large solar filament eruptions, and find that enduring flux cancellation at the neutral line of the filaments often triggers their eruptions. This corresponds to the finding that persistent flux cancellation at the neutral is the cause of jet-producing minifilament eruptions. Thus our observations support coronal jets being miniature version of CMEs.

Evolution of a Minifilament and Jet

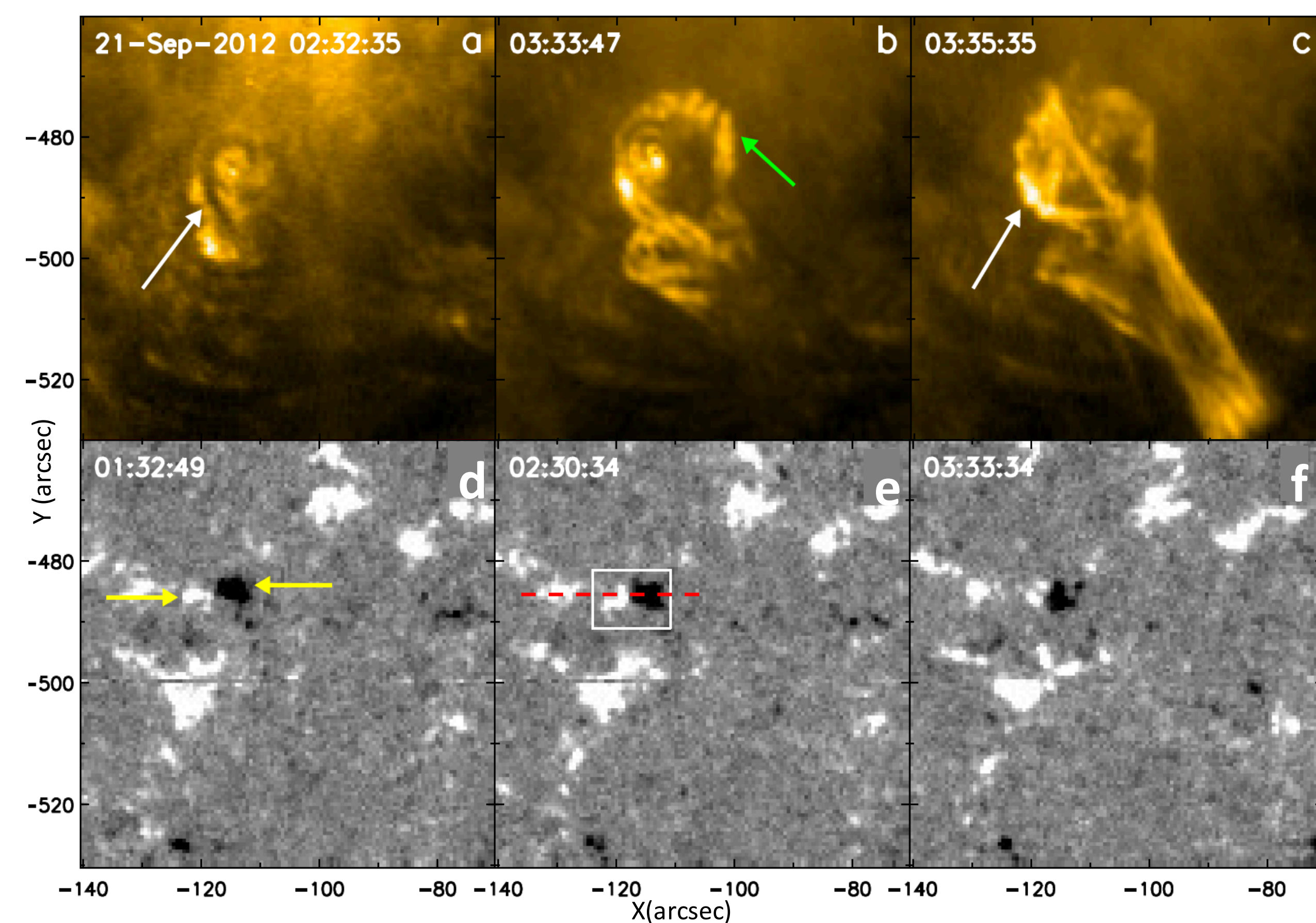


Fig.1. Quiet-region jet: (a-c) SDO/AIA 171 Å intensity images. (d-f) SDO/HMI magnetograms. The white arrows in (a) and (c) show the minifilament and jet bright point, respectively. The green arrow in (b) points to base brightenings from external reconnection. The yellow arrows in (d) show the converging positive and negative flux clumps. In (e) the boxed region shows the area measured for the magnetic flux-time plot in Fig 2(a) and the red dashed line shows the east-west cut for the time-distance map of Fig. 2(b).

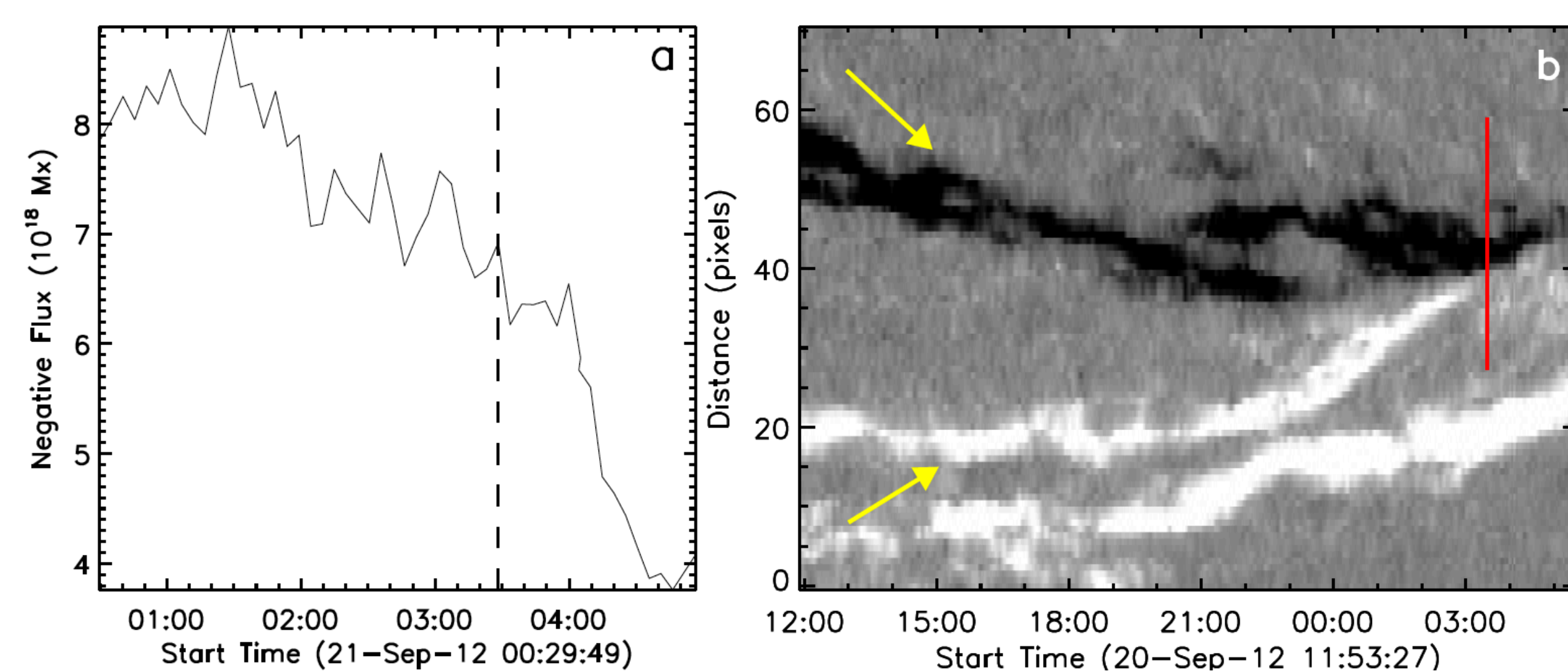


Fig 2. Magnetic flux evolution of jet: Panel (a) shows the negative flux as a function of time from inside the box of Fig. 1(e). The dashed line shows the jet eruption time. Panel (b) shows the time-distance map of magnetic flux along the dashed line of Fig. 1(e). The arrows point to the flux patches that converged and canceled over 18 hours before and during jet eruption. The red line shows the jet eruption time (03:33 UT).

Evolution of a filament

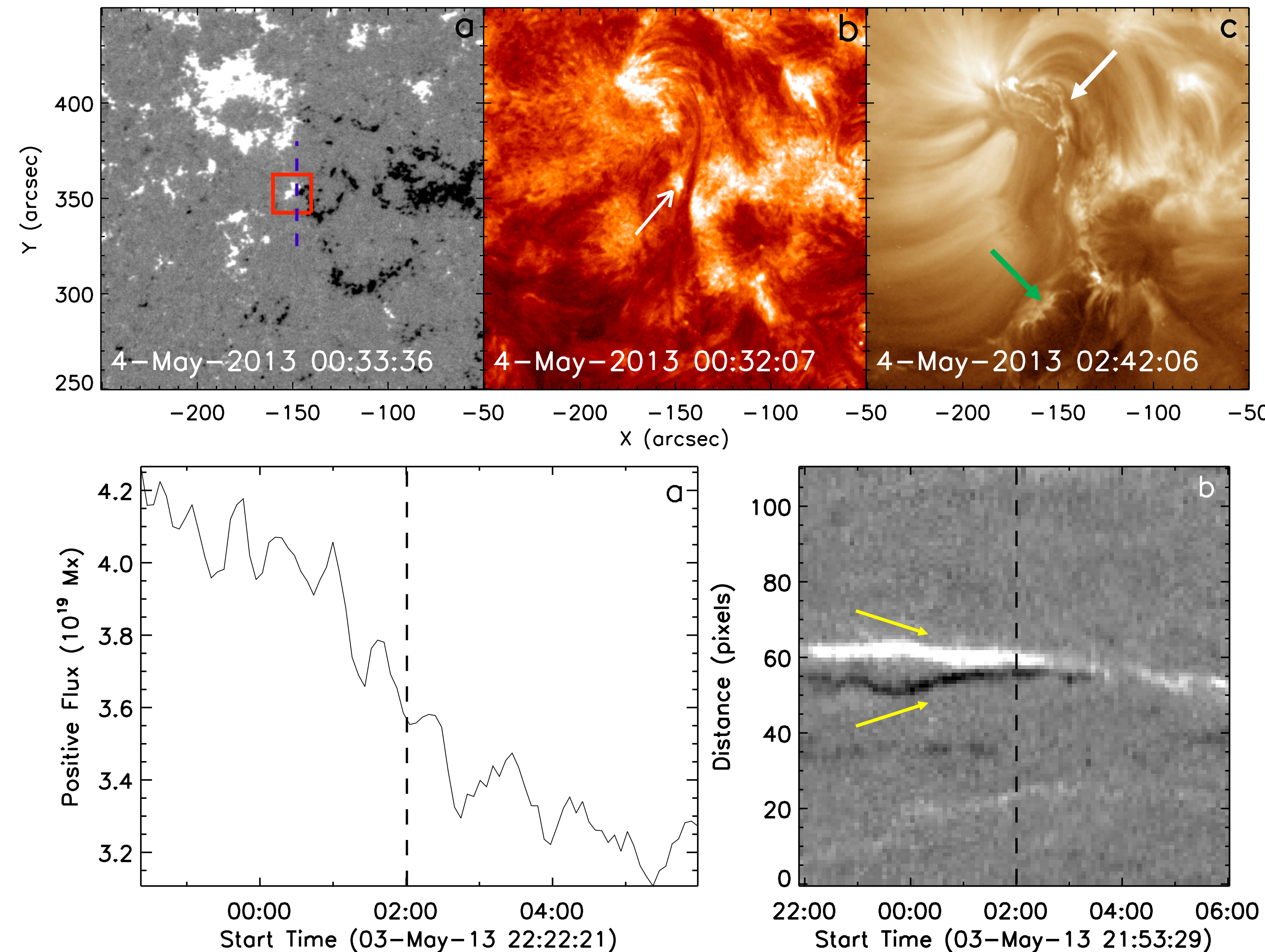
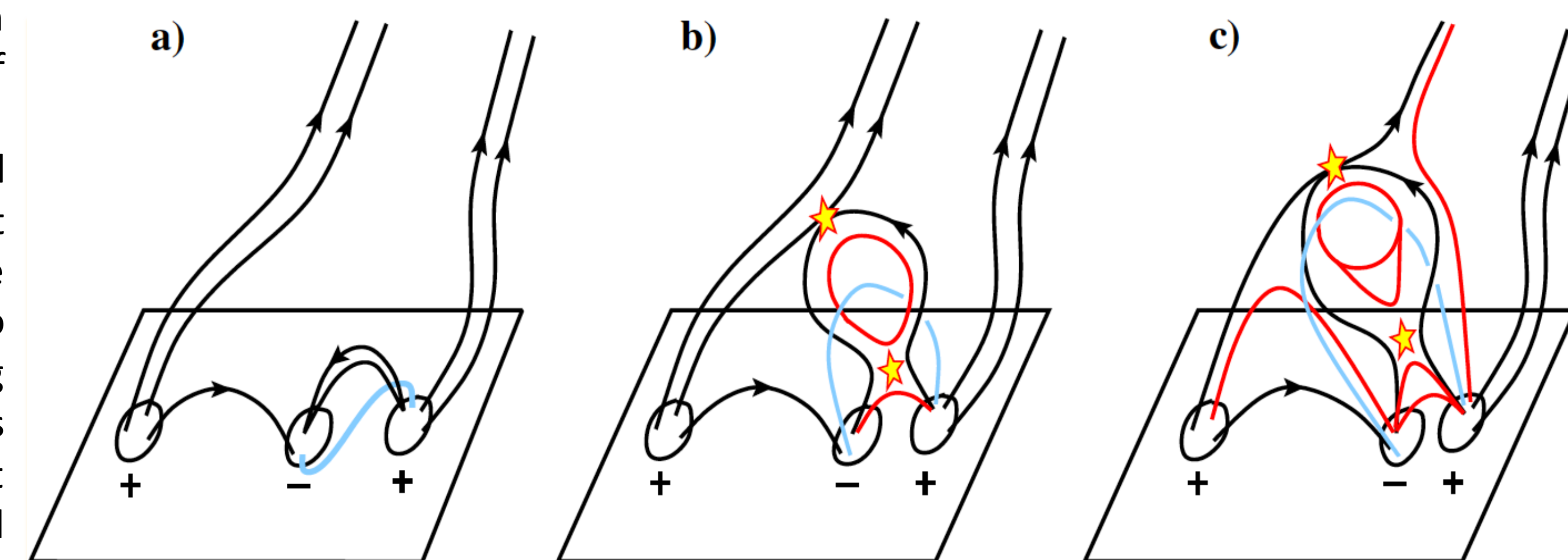


Fig.3. Quiet-region filament eruption: (a) SDO/HMI magnetograms. The boxed region shows the area measured for the magnetic flux-time plot in Fig 4(a) and the blue line shows the north-south cut for the time-distance map of Fig. 4(b). (b-c) SDO/AIA 304 and 193 Å intensity images, respectively. The white arrow in (b) shows the onset brightening. The green and white arrows in (c) point to dimming and flare arcade, respectively.

Fig 4. Magnetic flux evolution of filament: Panel (a) shows the positive flux as a function of time from inside the box of Fig. 3(a). The dashed line shows the eruption time. Panel (b) shows the time-distance map of magnetic flux along the blue dashed line of Fig. 3(a). The arrows point to the flux patches that converged and canceled over 6 hours before and during filament eruption. The black line shows the eruption time.

Interpretation

- The (mini)filament (blue) initially resides in sheared/twisted field between patches of majority (positive) and minority (negative) flux. These two flux patches converge and cancel with each other. Continuous flux cancellation at the neutral line eventually destabilizes the filament field to erupt outwards and undergo external reconnection with the surrounding coronal field. The external reconnection opens the erupting closed field, allowing hot reconnection-heated material and cool minifilament material to escape along the far-reaching field as the jet spire.
- Similarly we find that flux cancellation is usually the trigger of CME-producing large filament eruptions. The main difference are (a) size scale, and (b) in jets, the erupting flux rope often is totally consumed by the external reconnection, while in larger-scale filament eruptions the flux rope escapes as part of a CME¹.



References

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